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Teledermatology in a Capitated Delivery System Using Distributed Information Architecture: Design and Development

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ABSTRACT

Objective: This report describes the design, development, and technical evaluation of a teledermatology system utilizing digital images and electronic forms captured through, stored on, and viewed through a common web server in an urban capitated delivery system.

Materials and Methods: The authors designed a system whereby a primary care physician was able to seek a dermatologic consultation electronically, provide the specialist with digital images acquired according to a standardized protocol, and review the specialist response within 2 business days of the request. The settings were two primary care practices in eastern Massachusetts that were affiliated with a large integrated delivery system. Technical evaluation of the effectiveness of the system involved 18 patients. Main outcome measures included physician and patient satisfaction and comfort and efficiency of care delivery.

Results: In 15 cases, the consultant dermatologist was comfortable in providing definitive diagnosis and treatment recommendations. In 3 cases, additional information (laboratory studies or more history) was requested. There were no instances where the dermatologist felt that a face-to-face visit was necessary.

Conclusions: This novel approach shows promise for the delivery of specialist expertise via the internet. Cost-effectiveness studies may be necessary for more widespread implementation.

INTRODUCTION

THIS ARTICLE DESCRIBES THE DESIGN, development, and initial technical evaluation of a teledermatology system create within an urban integrated delivery system. Partners HealthCare System, Inc., is composed of three tertiary care hospitals and several community hospitals, clinics, and physician practices. Presented here is a preliminary evaluation of the effectiveness of the system.

Up to 87% of primary care physicians (PCPs) in practice today have had between 1 week and 1 month of formal dermatology training.[1] The need for efficient management of skin diseases is underscored by the finding that, when viewing a slide set of 20 common dermatoses, PCPs make the correct diagnosis about 50% of the time compared with 90% to 95% for dermatologists.[1,2] Dermatologists viewing a set of still digital images and dermatologists viewing patients' skin agree on a diagnosis ~80% of the time.[3] Face-to-face clinicians are also in agreement ~80% to 90% of the time when examin-

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ing a group of patients with varying cutaneous diagnoses.[4–6] Patients are particularly concerned about the appearance of their skin, and skin disease affects wellbeing in profound ways.[7–9] Third-party payers are increasingly concerned with patient satisfaction and with quality-of-care measures, as well as cost-effectiveness and efficiency.[10–14] All these trends have resulted in a close examination of methods that enable primary providers to deliver higher-quality care without the additional cost of referrals to specialists.[15–17]

It may be argued that physicians are familiar and comfortable with the care delivery mode characterized as store-and-forward technology, whether or not they use the term. Indeed, voice mail, fax, courier services, and e-mail all represent store-and-forward modalities. The Internet has not been studied as extensively as a communications tools for the delivery of care as other means of care delivery because it is new and became widely available only recently.

It may be argued that building blocks are required for an effective teledermatology system. It should be convenient for a referring practitioner to enter data and append images; the data collected should be standardized to maximize the historical details that would normally be obtained in an in-person interview; the data must emphasize nonvisual aspects of the physical exam to which the consultant dermatologist will not have access; there should be a standard method for image acquisition, and the method should interfere only minimally with office workflow and be of minimal inconvenience to patients and clinicians. Moreover, there should be a centralized database for storage of medical records and images providing access for both the specialists and the referring practitioner; the specialist must have convenient, multipoint access to the same information as the referring practitioner; and he or she must be able to provide prompt feedback in order to augment patient care. The reasons for this are convenience, practicality, and especially risk management.[18–22]

Software and communications platforms for this process are still being designed and defined.[23,24] Some have used point-to-point connections and software that has the functionality of electronic mail with attachments. Others have created specific software solutions for telemedicine generally and teledermatology specifically. These software solutions often combine certain features of the electronic medical record with the capability of uploading images and image viewing. Current review of available products leads to the conclusion that no standard solution is in widespread use at this time.[25–28]

This article describes a systematic approach for combining all of the above features to achieve ease of use for both PCPs and specialists without regard to time or geographic constraints. Further, the demonstration utilized off-the-shelf personal computers and components, eliminating the need for video cards or other computer modification.

Our system uses the Internet as a communications vehicle and a World Wide Web browser as the presentation software (Fig. 1). The primary care site and the specialist's viewing station use the Web browser for their interactions. Images captured at the primary care site are downloaded to a server via the browser. In addition, we developed a standardized history and methods for identification of image area, as well as a protocol for image acquisition. A centralized Web server stores images and histories. The specialist can view history and images easily from any computer with an Internet connection. The secure system requires a user name and a password for access, and it uses secure socket layer encryption for each transaction. It is further secured by segmentation of access, limiting the specific information that can be downloaded by potential users based on their identification as referring physician, specialist, or imaging technician.

All primary care sites (affiliates of Partners HealthCare System, Inc.) had expressed an urgent need for expanded dermatologic coverage and became committed participants in this new health care delivery model. The development of this Web-based teledermatology system was undertaken to address these unmet needs. The software was developed in collaboration with Global Telemedix, Westford, MA using Lotus Notes™ on a Domino™ server. The software platform is being adapted to run on any World Wide Web server.

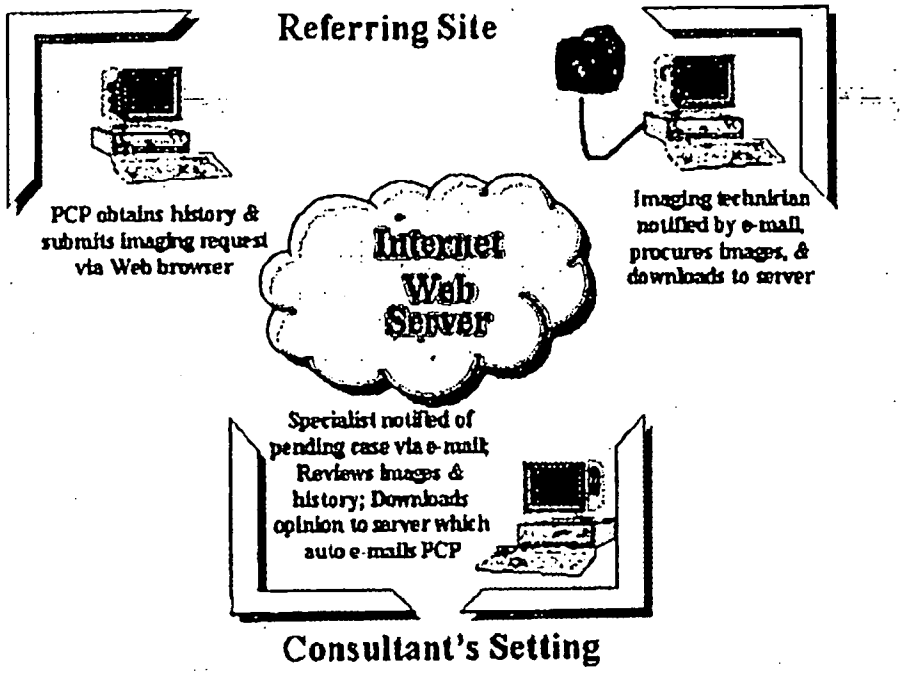


FIG. 1. Teledermatology electronic work flow.

PATIENTS AND METHODS

Study Subjects

After the system was installed at two sites, patient volunteers presenting with skin-related complaints at the Women's Health Associates at Massachusetts General Hospital and the Cape Ann Medical Center in Gloucester, Massachusetts, were invited to participate in a technical evaluation of the system. After giving informed consent, patients were randomized into two groups: One group underwent digital imaging of skin conditions, the other received routine care as determined by the PCP. Initially, patients who chose to participate in the study had a skin condition diagnosed by the PCP. All skin conditions were eligible for inclusion in the preliminary evaluation except for acne, warts, and skin tags. Also, if patients experienced fever and/or chills as a result of the skin condition, they were not invited to take part in the study.

Service Process

History acquisition and consultation request. Following informed consent, if the patient were to undergo imaging, the PCP made note of the area to be imaged either on a paper form or directly on a Web-based form developed for that purpose (Fig. 2). A PCP recorded a dermatology-specific patient history to accompany the request for imaging (Fig. 3). The consultation request also included the PCP's most likely diagnosis and a treatment plan. Previously trained imaging technicians employed by Partners Telemedicine and assigned to the participating sites obtained the requested images for uploading to the server for later review by the specialist.

Image acquisition. Image capture was achieved using Nikon E2N digital cameras equipped with Nikon 105MM F2.8 lenses and Canfield Clinical Systems CCS Twin Flashes. The Nikon E2N was chosen because of its ability to render digital images providing the same aspect ratios as 35-mm film. A critical component of the imaging protocol was adherence to specific aspect ratios appropriate for imaging of lesions. Images were uploaded to a Web server and displayed on a standard PC monitor utilizing at least 800 × 600 pixel resolution and 32-bit color (Hewlett Packard HP Vectra 5 personal computer with a 133 Mz Pentium processor and 64 Mb of RAM. A Matrox Millenium graphics card

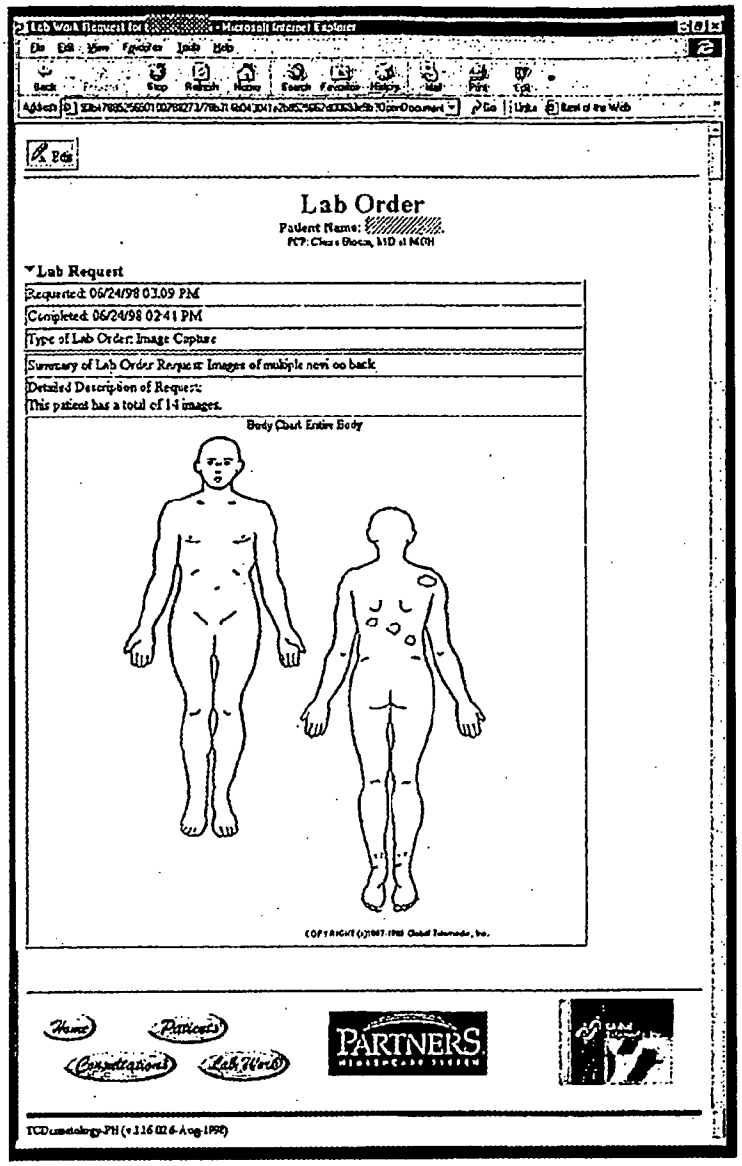
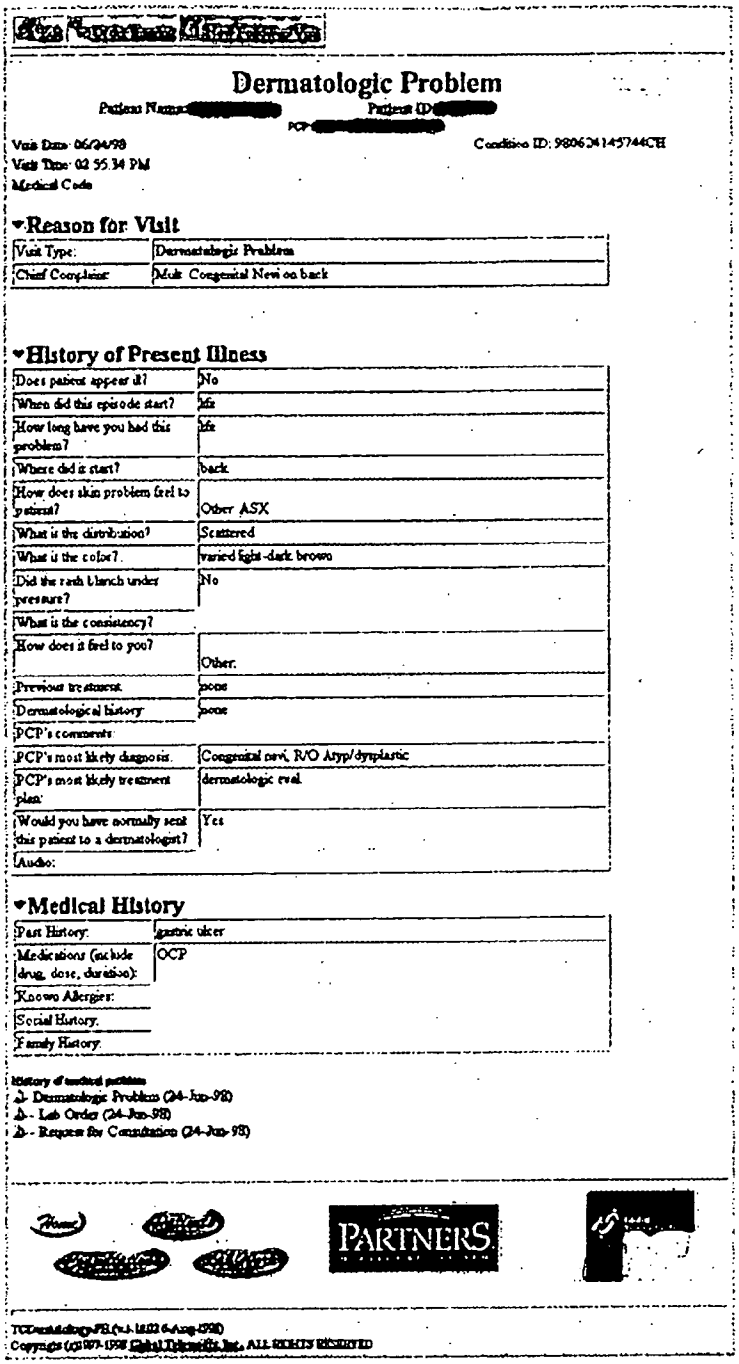


FIG. 2. Lab order.

was installed. The imaging monitor was a Mitsubishi Diamond Scan 20-inch monitor).

Images were acquired according to a standardized protocol developed by the Department of Dermatology (Fig. 4; complete protocol available from the corresponding author upon request). This protocol delineated explicit instructions for photography of the scalp, face, oral cavity, neck, trunk, extremities, anogenital areas, hands, and feet, including aspect ratios and angles of photography. In developing the imaging protocol, the aim was to produce a set of guidelines that required minimal interpretation on the part of the imaging technicians, none of whom were professional photographers.

Imaging technicians obtained a reproducible series of images for each case based on the anatomic location of the skin condition. Images were taken at a central location (imaging area) or in the examining room. The technician confirmed image clarity and reproduction ratio prior to releasing the patient. Because this was a preliminary technical evaluation, other important photographic elements such as color



Dermatologic Problem

Patient Name: [redacted] Patient ID: [redacted]

PCP: [redacted]

Visit Date: 06/24/98 Condition ID: 980624145744CH

Visit Time: 02:55:34 PM

Medical Code

Reason for Visit

Visit Type:	Dermatologic Problem
Chief Complaint:	Mult. Congenital Nevi on back

History of Present Illness

Does patient appear ill?	No
When did this episode start?	life
How long have you had this problem?	life
Where did it start?	back
How does skin problem feel to patient?	Other: ASX
What is the distribution?	Scattered
What is the color?	varied light-dark brown
Did the rash blanch under pressure?	No
What is the consistency?	
How does it feel to you?	Other:
Previous treatment:	none
Dermatological history:	none
PCP's comments:	
PCP's most likely diagnosis:	Congenital nevi, R/O Atyp/dysplastic
PCP's most likely treatment plan:	dermatologic eval.
Would you have normally sent this patient to a dermatologist?	Yes
Audio:	

Medical History

Past History:	gastric ulcer
Medications (include drug, dose, duration):	OCP
Known Allergies:	
Social History:	
Family History:	

History of medical problems

- Dermatologic Problem (24-Jun-98)
- Lab Order (24-Jun-98)
- Request for Consultation (24-Jun-98)

PARTNERS

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FIG. 3. Request for consultation.

and resolution were not specifically addressed by the technicians but were subject to critique by the evaluating specialists.

Only patient record numbers identified the images. Connectivity between sites was achieved using Transmission Control Protocol/Internet Protocol (TCP/IP) over a wide area data network with a minimum of 1.5 mbps between sites. Participating dermatologists were free to view cases over the Internet from their home, and they did so using either a DirectTV™ satellite link or a cable modem. Up-

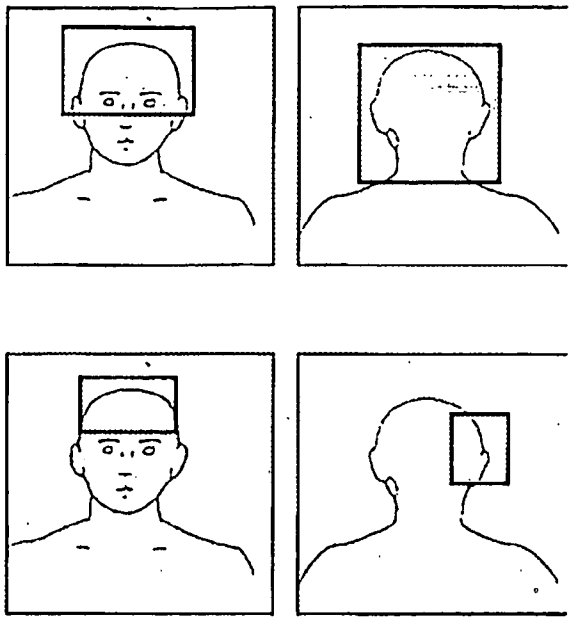

FIG. 4. Image protocol example: scalp (top/back/sides). General considerations: The patient should be seated. The head should be inclined forward or rotated so that the area to be imaged lies on a plane with the camera back. The patient may assist by helping to part the hair to better expose scalp, or the hair may be taped or otherwise secured away from the affected area. The patient should remove jewelry and be draped to avoid visual distractions of clothing. Image 1: Image the general scalp area affected (1:8 ratio). Images 2–4: Image closeups of the affected area (1:4, 1:2, and 1:1 ratio). Additional special images: A fifth photograph (1:4 or 1:2) should be made at an oblique 45° angle.

loading of images from the digital camera to the PC took ~20 s per image, and transmission to the server took ≤40 s. Images were saved as medium-resolution JPEG files occupying ~700 kb of space for each. An automatic electronic message to one of the two dermatologists (Da or Db) alerted him or her that a case was ready for review. Cases were randomly assigned to one of the dermatologists by the imaging technician.

Imaging technicians at both sites maintained a log of a patient's identification number, study number, and dates of all surveys done. In addition, the technician maintained a daily occurrence log for any problems that arose throughout the process from consent to receipt of consult by the PCP. These occurrences were phoned to the study coordinator at Partners Telemedicine for immediate resolution.

Specialist review. Upon electronic notification of a pending consultation, the two board-certified dermatologists reviewed the patient history and images and rendered an opinion using a 2-business-day turnaround time in routine cases or a 1-business-day turnaround time upon PCP's request (Fig. 5). In this study, no PCP requested the 1-day turnaround. Following completion of the review, an e-mail message, sent automatically following specialist completion of the consultation, alerted the PCP that the consultation was ready for viewing on the server.

Specialist responses to PCPs were grouped into three categories: (1) a diagnosis and treatment plan, (2) a request for additional information or images, and (3) an inability to determine the condition from the images provided and a recommendation that the patient be seen by a "live" dermatologist. Additionally, if the PCP thought that further examination and treatment were needed, the patient was informed that an appointment would be made for him or her with a local dermatologist. Partners Telemedicine study personnel followed up on all such cases to ensure that an appointment was made. Routine follow-up calls were made on a technical evaluation patients to assess their progress and opinion regarding their care.

Evaluation tools. Patients were queried as to satisfaction with the overall physician visit, adequacy of explanations, answers to questions and concerns about the photographic study, courtesy and respect of office personnel including the imaging technician, comfort with this new method of care, and satisfaction with time spent taking pictures. Patients ranked their satisfaction from 5 (strongly agree) to 1 (strongly disagree). PCPs were polled as to their comfort with the equipment and procedures for remote consultation, convenience of teleconsultation, timelineness of teleconsultations, quality of the teleconsultants' diagnosis and recommended treatment, likelihood of continued use of teleconsultations, and comfort with the security of teleconsultations.

RESULTS

Twelve PCPs referred patients, and no patient refused to participate in the study.

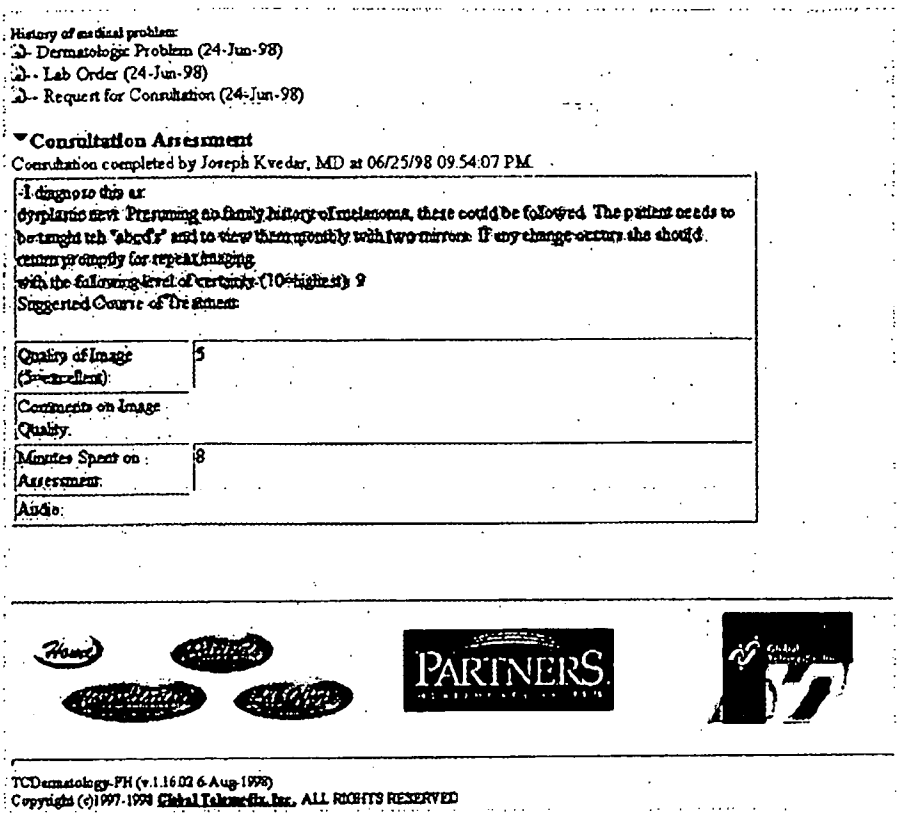

FIG. 5. Specialist response.

The evaluation phase lasted 16 working days. A total of 18 patients were seen. The breakdown of those figures between the two sites was as follows: MGH saw 11 patients, and Cape Ann saw 7 patients. Fifteen female and 3 male patients were enrolled.

Physicians and patients responded to questionnaires concerning their reaction to the program. The experience was generally positive for participants. Asked to report their satisfaction with this new method for conducting dermatologic examination, almost all patients thought that their concerns were addressed, they were comfortable with this new method of care, and the overall experience was satisfactory (Tables 1 and 2). Satisfaction concerning care between the study patients who were imaged and control patients who were not was not qualitatively different. Physician responses (Table 3) were more reserved. The overwhelming majority wished to continue teleconsultations when the service becomes available on a regular basis (76.9% "strongly agree," 23.1% "agree").

The dermatologists graded the quality of images on a scale of 1 to 5, certainty of diagnosis on a scale of 1 to 10, and the time spent assessing the case. Image-quality assessment ranged from 5 (n = 5) to 2 (n = 2), with a mean of 3.8. Mean certainty of diagnosis was 7.4 with a range of 2 (n = 1) to 9 (n = 7). Time spent on each case by the dermatologist ranged from 3 min (n = 1) to 10 min (n = 7), with a mean time to completion of 6.8 min. In 82% of cases, the dermatologist was confident in making a diagnosis and treatment recommendation. In 18% of cases, the dermatologist requested additional information or images. In no case did the specialist believe that a face-to-face encounter was required because of an inability to read the images. Finally, the number of images stored for each case was tracked. The mean number of images uploaded was 6.1, ranging from 3 (n = 2) to 9 (n = 4). In most instances, higher numbers of images correlated with imaging of multiple sites on a patient.

TABLE 1. STUDY PATIENTS' QUESTIONNAIRE

Question	Overall Score	MGH Score	Cape Ann Score
Overall I was satisfied with my visit to my physician today as compared to similar visits to this doctor.	4.56	4.55	4.57
I was satisfied that my questions and/or concerns about this new photographing study were addressed and answered.	4.56	4.55	4.71
I was given respect and courtesy by all office personnel, including the person who took the pictures.	4.78	4.73	4.86
I was comfortable with this new process of care.	4.56	4.36	4.86
I was satisfied with the amount of time that was spent in taking the pictures.	4.22	4.55	3.86

DISCUSSION

The system centralizes data in one location and allows retrieval of information from the centralized storage area. This permits efficient storage and retrieval of information, including appropriate history and images, as well as measuring outcomes.

The presentation software for this project is the ubiquitous Web browser. Generally, Microsoft's Internet Explorer and Netscape's Navigator programs are bundled as standard software on a personal computer. The system employed here allows the vast majority of PCs available off-the-shelf to be used as work stations. This dramatically lowers the cost of image interpretation while providing an environment in which a practitioner can interpret images and work at any work station within a network or at home.

Technology requirements for image acquisition are minimal. Again, an off-the-shelf personal computer is appropriate. The digital capture device can vary depending on the needs of the system. In this case, we chose a high-resolution photographic device as a benchmark because of the need to acquire high-resolution close-up images and to adhere to an imaging protocol. The digital capture device was the single most expensive component, but the price is going down. Currently we are investigating image capture devices for <$1000.

The use of the Internet as a telecommunication vehicle has both positive and negative implications. One positive implication is reduced cost. The structure of the Internet is such that the cost of being on the network is low in most places in the world (requiring a local phone call and a monthly subscription fee for an Internet service provider). Another advantage is the ubiquity of client and server software for Web applications. Potential negatives of using the Internet have to do with bandwidth, security, and quality of service. In this study bandwidth was not particularly significant, as image sizes

TABLE 2. CONTROL PATIENTS' QUESTIONNAIRE

Question	Overall Score	MGH Score	Cape Ann Score
Overall I was satisfied with my visit to my physician today.	4.3	4.76	3.43
I was satisfied that my questions and/or concerns about this new study were addressed and answered.	4.45	4.54	4.29
I was satisfied that I was given respect and courtesy by office personnel, both medical and support staff.	4.55	4.85	4.00
I was comfortable with the existing way care is given by my physician.	4.55	4.77	4.14

TABLE 3. PRIMARY CARE PHYSICIAN SATISFACTION WITH TELEDERMATOLOGY

Question	Overall Score
I am comfortable with the use of the equipment and procedures for obtaining a remote consult.	4.5
Teleconsult was more convenient than a traditional consult	3.5
Teleconsults were less timely than traditional consults.	2.6
I am satisfied with the quality of the teleconsultants' diagnosis and recommended treatment.	4.1
I am more likely to use teleconsults (given the same group of patients) because they provide more diagnostic certainty.	3.5
I am more likely to use teleconsults (given the same group of patients) because they are convenient.	4.6
I am comfortable with the security of medical information transmitted in teleconsults as compared to the privacy and security of medical information provided in traditional consults.	4.3
I would like to continue using teleconsults when this study is over.	4.8

were relatively small, and the transactions took place during low network traffic hours. Although we have been able to transmit, retrieve, and review images over a 56-kbps modem connection, the system is optimized with a minimum of 128 kbps transmission speed.

The main concern with Internet use in this application is security of information. This system applies several layers of security, but the security of any record in any health care system is at risk at any time. This program utilized the most sophisticated encryption available as a standard procedure.

The project demonstrated that the quality of service of the Internet and associated hardware–software applications are generally sufficient for a consultative practice. It should be pointed out that no decisions made during this trial were immediate or life-or-death decisions. Rather, the explicit commitment to our PCPs was a 2-business-day evaluation. This allowed for minimal technologic service disruptions to occur without affecting level of service. The endorsement of the Internet for this activity does not imply endorsement of the Internet for activities that involve more time-critical and mission-critical applications.

Another noteworthy feature of this application is our use of an imaging technician and an imaging protocol for image acquisition. We considered several models in devising the system, including the ability or desirability of PCPs acquiring their own images, the use of highly skilled allied health care professionals to acquire images, and the use of technicians. We chose to use technicians for several reasons. From an economic prospective, it is desirable to create systems in which the cost of labor for implementation is lower. Another aspect of the application is efficiency for the PCP. Although some PCPs initially raised concerns about filling out relatively lengthy history forms, they quickly adapted to this element of the case flow. Subsequent to the evaluation phase, one PCP reported that filling out the form initially took ≤5 minutes; with regular utilization, that time has been reduced to 1–2 min. Further refinement of the Web-based history forms will reduce the actual typing by utilization of "pick lists."

In many practices, existing personnel of a practice could be trained to acquire and download the images as a part of their normal functioning. In the technical evaluation phase of this deployment, technicians worked full time on debugging the system, explaining trial information to patients, training PCPs, and completing patient questionaires. In the implementation phase, these technicians are cross-trained to perform a variety of routines within the clinical environment.

Patients approved the use of this technology, particularly at the remote site (Cape Ann Medical Center in Gloucester, Massachusetts, a distance of 58 miles from the tertiary care center). They valued the convenience and rapid treatment, and they believed that their PCP was giving them sound medical advice. Thus, the main change agents in the modification of the health care process are likely to be primary care doctors.

Another factor regarding this research is the restriction of this activity to urban and suburban areas. This is new ground for telemedicine applications to break. Most telemedicine applications have been utilized in one of four markets (underserved rural, military, incarcerated, and international). These markets share wide geographic disbursement of patients and doctors or difficulty in patient or physician transport as the major issues for which telemedicine has been

viewed as a solution. In this case, the investigation centered on the use of telemedicine as an efficiency tool in an urban environment where access to care is generally not a problem.

Further research in this area will include an assessment of whether this approach to care efficiency in an urban area has merit. Measurements will include quality of outcomes and cost of service.

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REFERENCES

1. Kirsner RS, Federman DG. Lack of correlation between internists' ability in dermatology and their patterns of treating patients with skin disease. *Arch Dermatol* 1996;132:1043–1046.
2. Ramsey DL, Fox AB. The ability of primary care physicians to recognize common dermatoses. *Arch Dermatol* 1981;117:620–622.
3. Kvedar JC, Edwards RA, Menn ER, et al. The substitution of digital images for dermatologic physical examination. *Arch Dermatol* 1997;133:161–167.
4. Lowitt MH, Kessler II, Kaufman CL, et al. Teledermatology and in-person examinations. *Arch Dermatol* 1998;134:471–476.
5. Perednia DA, Gaines JA, Rossum AC. Variability in physician assessment of lesions in cutaneous images and its implications for skin screening and computer-assisted diagnosis. *Arch Dermatol* 1992;128:357–364.
6. Whited JD, Horner RD, Hall RP, et al. The influence of history on interobserver agreement for diagnosing actinic keratoses and malignant skin lesions. *J Am Acad Dermatol* 1995;33:603–607.
7. Drake LA. Impact of onychomicosis on quality of life. *J Am Podiatr Med Assoc* 1997;87:507–511.
8. Finlay AY. Quality of life measurement in dermatology. *Br J Dermatol* 1997;136:305–314.
9. Ginsburg IH. The psychosocial impact of skin disease. *Dermatol Clin* 1996;14:473–484.
10. Clark RA, Rietschel RL. The cost of initiating appropriate therapy for skin diseases: A comparison of dermatologists and family physicians. *J Am Acad Dermatol* 1983;9:787–796.
11. Pariser RJ, Pariser DM. Primary care physicians' errors in handling cutaneous disorders. *J Am Acad Dermatol* 1987;17:239–245.
12. Bailit H, Federico J, McGivney W. Use of outcomes studies by a managed care organization: Valuing measured treatment effects. *Med Care* 1995;33:AS216–AS225.
13. Denton TA, Diamond GA. For goodness' sake: Expected therapeutic benefits as a basis for healthcare delivery. *Clin Chem* 1995;41:799–804.
14. Kirsner RS, Federman DG. Patient satisfaction: Quality of care from the patients' perspective. *Arch Dermatol* 1997;133:1427–1430.
15. Gabriel SE. Primary care: Specialists or generalists. *Mayo Clin Proc* 1996;74:415–416.
16. Brunner LK, McKnight MM. Are gatekeepers necessary? *Best Pract Benchmarking Healthc* 1997;2:52–56.
17. Hall RC. Ethical and legal implications of managed care. *Gen Hosp Psychiatry* 1997;19:200–208.
18. Plumeri PA. Managed care and risk management. *Gastroenterol Clin North Am* 1997;24:895–910.
19. Rees AM. Communication in the physician-patient relationship. *Bull Med Lib Assoc* 1993;81:1–10.
20. What are the risk management issues surrounding telemedicine. Risk Management Foundation. *http://www.rmf.org/b4269.html*
21. Shotwell LF. Taming liability of telemedicine transactions: Technology adoption poses catch-22 for providers. Arent Fox Kintner Plotkin & Kahn. *http://www.arentfox.com/telemed/articles/tamingliab.html*
22. Allaert FA, Dusserre L. Legal requirements for teleassistance and tele-medicine. *Medinfo* 1995;8Pt2:1593–1595.
23. Filiberti D, Wallace J, Koteeswaran R, Neft D. A telemedicine transaction model. *Telemed J* 1995;1:237–247.
24. Vidmar DA. Plea for standardization in teledermatology: A worm's eye view. *Telemed J* 1997;3:173–178.
25. Balas EA, Jaffrey F, Kuperman GJ, et al. Electronic communication with patients: Evaluation of distance medicine technology. *JAMA* 1997;278:152–159.
26. Cimino JJ, Socratous SA, Clayton PD. Internet as clinical information system: Application development using the world wide web. *J Am Med Inform Assoc* 1995;2:273–284.
27. Afrin LB, Kuppuswamy V, Slater B, Stuart RK. Electronic clinical trial protocol distribution via the world wide web: A prototype for reducing costs and errors, improving accrual, and saving trees. *J Am Med Inform Assoc* 1997;4:25–35.
28. Schosser R, Weiss C, Messmer K. A local area network for medical research; planning, realization and experience. *Methods Inf Med* 1991;30:53–64.

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